SPIDER

Mark 3

Stabilized **P**anoramic **I**ntruder
Detection and **R**ecognition System

USER'S MANUAL

TABLE OF CONTENTS

1. SCOPE

This User's Manual contains the information needed to operate and maintain the SPIDER Mark 3 Stabilized Panoramic Intruder Detection and Recognition System at the Organizational (O) Level.

The SPIDER System is a gyro stabilized two axes day/night panoramic scanning System, which provides automatic change detection in a wide panoramic view. The SPIDER System includes CCD and FLIR cameras with zoom lenses, Laser Range Finder and Laser Pointer. The SPIDER performs completely passive electro-optical panoramic detection scans. The SPIDER has two primary Modes of Operation: Panoramic Scan Mode for intruder detection and Observation Mode for intruder recognition. Target range can be measured using an eyesafe Laser Range Finder and target location can be calculated and displayed. The Laser Pointer can designate the target for mission forces.

The SPIDER System consists of three Subsystem units:
A. The Scanner subsystem which includes the two axes Gimbal Assembly and the Optronic Payload with the sensors.
B. The Control and Display Unit (CDU) subsystem which includes a PC with a monitor, a Mouse, Keyboard and a Joystick and an Interface Box (IFB).
C. The Cables subsystem which consists of three main cables: a cable that connects the Payload with the Gimbal, a cable that connects the Gimbal with the IFB, and a cable that connects the IFB with the PC.

This User's Manual includes a description of the SPIDER System as well as the System's Modes of Operation and System Characteristics. Also included are detailed instructions for the unpacking of the System, installation and preparation for use and set up before operation. In addition to System operation instructions, the Operator will find maintenance and servicing instructions, and ideas for System troubleshooting. Also included in this User's Manual are instructions for removing the System from the platform and preparation for shipment.

Please note that all of the above noted descriptions include references to relevant figures and tables.

Figure 1 shows the SPIDER System General View.

Figure 1: SPIDER System General View

2. SPIDER SYSTEM DESCRIPTION

2.1. System Applications

The SPIDER is recommended for a myriad of possible applications, including but not limited of the following:

- Terrorist Intruder Detection.
- Opposing Ground Troops Detection.
- Border Control (against Smuggling, Illegal Immigration etc.).
- Security of Sensitive Military Installations.
- Perimeter Security.
- Coastal Surveillance (including Small Boat Detection, Swimmer Detection, etc.).
- Surveillance of High-Value Sensitive Facilities (Airports, Power Plants, Fuel Storage Depots, Oil Refineries, Water Reservoirs, etc.).

The SPIDER may be installed on a variety of different platforms, including but not limited to the following:

- Ground Installations.
- High Masts.
- Observation Towers.
- Land Vehicles.
- Maritime Boats.

The SPIDER Main Features include the following:

- Real-time automatic intruder detection.
- Day/Night capability.
- Gyro stabilized high speed scanning capability.
- Passive electro-optical detection.
- Provides panoramic view of surveyed area
- Multiple target detection.
- Target ranging and position calculation.
- Audible alarm.
- Wide Field of Regard (360° continuous in azimuth and ±40° in Elevation).
- Intruder recognition capability using zoom-in (Observation Mode).
- RS-422 serial communication to external Systems.
- Scanner is designed in two field-replaceable units which can be back-carried.

2.2. System Description

The SPIDER is an automatic panoramic two axes day / night optronic Scanning System which is remotely operated by a single Operator. The System enables human and vehicles intruder detection, observation, recognition and range finding in two primary modes of operation.

- Panoramic Scan Mode for intruder detection.
- Observation Mode for intruder recognition and identification.

During operation of the SPIDER, the panoramic scene and/or observation video pictures are simultaneously or separately displayed on a high-resolution LCD monitor. Suspicious targets are automatically marked on the screen, enabling the Operator to select and recognize the target and measure range and location coordinates for making tactical decisions. An audio alarm can be activated if opted.

The Panoramic Scan Mode is used for intruder detection, and incorporates sophisticated real time motion detection algorithms allowing simultaneous detection of multiple targets. During Panoramic Scan Mode, the Field of Regard (FOR) in azimuth and elevation axes are selectable, along with the optical sensor's Field of View (FOV).

The Observation Mode is used for intruder recognition. When the Observation Mode is selected, the Scanner can be controlled using the Operator's Joystick. In addition, the Operator may use the zoom function of the CCD or FLIR cameras for continuous control of the FOV.

The SPIDER's Scanner is remotely controlled by the Control and Display Unit (CDU). The CDU is based on a personal computer (PC) and is generally located either in the System's control room or on the mission vehicle, depending on the platform in use. The Scanner and the CDU are connected to one another by one cable with the following lines:

- Control signals, data link and video outputs.
- Scanner Power source.

Figure 2.1 shows the SPIDER Block Diagram.

2.3. System Configuration.

Figure 2.2 shows the SPIDER System Configuration and Interconnection Diagram.

The SPIDER contains three Subsystems:

- The Scanner Subsystem which includes the Gimbal Assembly and the Optronic Payload. This Subsystem includes the SPIDER's sensors, servo modules, Slip Ring unit and electronic cards.
- The Control and Display Unit (CDU) Subsystem, which includes the main computer with all the essential equipment: LCD monitor, Keyboard, video cards, Mouse and joystick, as well as the Interface Box (IFB), and UPS (optional).
- The Cables Subsystem which consists of three main cables: a cable (W4) that connects the Payload with the Gimbal, a cable (W1) that connects the Gimbal with the IFB, and a cable (W2) that connects the IFB with the PC.

2.3.1. The Scanner Subsystem

Figure 2.3 shows the SPIDER Scanner Subsystem.

The Gimbal Assembly

Figure 2.4 shows the SPIDER Gimbal Assembly.

1. The Gimbal Assembly is a stabilized two-axes Gimbal System that includes the following components:

a. Elevation (inner) Gimbal which serves as an optical bench, includes fast installation mechanism, and a Connector to the payload cable (W4).
b. Azimuth (outer) Gimbal, includes a Connector to W1 cable.
c. Gimbal's torquers and shaft encoders.
d. Two degrees of freedom Miniature gyro and a gyro electronic card.
e. Electronic cards: CPU, Analog Card, Power Supply and IAIM (Inertial Angular Integration Measurement) card, Fuse Card, Sync Card and Electronic Level Unit.
f. Slip Ring unit/ Elapse time meter and a bubble-leveling device.
g. Three mechanical stoppers for System transportation.

2. The Scanner Subsystem achieves its stability from the stabilized Gimbal Assembly. Stabilization is needed to compensate for disturbances

when the SPIDER operates in a vibrating environment, such as masts and vehicles.

3. The Stabilization servo loops consist of the following modules:

   a. A miniature, dual axis rate-integrating gyro with its Gyro Card, performing as the inertial stabilization sensor. The gyro output is transferred to the analog card as a feedback signal to the control loops.

   b. The Analog Card contains servo compensation networks including gain/phase analog filters and power amplifiers for the torquers.

The analog card is designed to ensure the required band-width (gain and phase margin).

   c. The Analog Card outputs control the Gimbal rates through torques generated in the Gimbal torquers.

   d. The azimuth and elevation Gimbal's positions are measured by an accurate shaft-encoders whose output is transferred to the CPU card.

   e. The Gyro Card output is integrated by the Inertial Angular Increment Measurement (IAIM) card in order to calculate L.O.S. angles and perform the inertial registration.

Figures 2.5 and 2.6 show the SPIDER Gimbal Assembly Mechanical Interface, and layout.

The Optronic Payload

Figure 2.7 shows the SPIDER Optronic Payload.

1. The Optronic Payload includes the SPIDER's four optical sensors:

- Thermal Imaging Unit (FLIR).
- Daylight colored CCD Camera.
- Laser Range Finder (Eye safe).
- Laser Pointer.

2. These sensors are mounted on an optical bench connected to the inner (elevation) Gimbal, by the fast installation mechanism.

3. The mechanical mounts are highly accurate in order to maintain sensor boresight.

4. The Payload Front and Rear Domes are mounted on to the optical bench in order to protect the optical sensors and electronic cards against external environmental conditions. The Front Dome has optical windows for the sensors. The payload is hermetically sealed.

5. The Optronic Payload has a mechanical interface which enables fast assembly and disassembly to the Gimbal subassembly, and it has a Connector to the W4 cable. It also has two handles for "O" level maintenance Removal.

Figure 2.8 shows the SPIDER Optronic Payload Mechanical Interface

Thermal Imaging Unit (FLIR) Camera

1. The FLIR camera consists of a 3rd generation high-resolution sensor operating in the 3-5 μm spectral range and continuous optical x22.5 zoom lens. The FLIR camera includes a closed cycle cooler allowing continuous operation with no limit in mission time.

2. The FLIR camera consists of the following main sub-assemblies:

   a. FPA/Dewar Assembly.
   b. Cryogenic Cooler
   c. FLIR Lens
   d. Micro-Scan Optical Mechanism
   e. FLIR Electronics (three cards).
   f. FLIR NUC Calibration Flag.

3. The FLIR Electronics includes the following functions:

- The Proximity Electronics PCB which contains all circuitry required to drive the FPA and provide the buffers and preamplifiers.

- The FLIR Processor & Video Electronics which provide the overall System control, calibration and FLIR System I/O and μ-scan control.

Daylight Colored CCD Camera

The Daylight CCD Camera is a high resolution colored CCD TV camera consisting of a 1/3" CCD detector with x16 zoom lens.

Laser Range Finder (LRF)

The eyesafe Laser Range Finder (LRF) is designed to measure the target range. With the LRF's data, the System is able to calculate the target location. The laser range finder is an eyesafe, 1.54 μm. wavelength.

Laser Pointer

The Laser Pointer enables pointing on a target with a 780nm Wavelength laser beam. This tool can be used in various tasks, for example – directing forces to the requested target etc.

Tripod (Optional)

Figure 2.9 shows the SPIDER Tripod.

1. The Tripod is the primary platform for the SPIDER System. In order to install the SPIDER Scanner on a Tripod, the Mechanical Interface is required. The Mechanical Interface includes the following interface parts:

   - Mechanical Plate with six holes for M8 bolts.
   - Interface Nut.

2. The Tripod is a Quickset Model QGT-3, enabling simple adjustment of the System's height and leveling during installation.

2.3.2. Control and Display Unit (CDU) Subsystem

The CDU Subsystem is based on a Personal Computer (PC), and an Interface Box (IFB).

Personal computer (PC)

Figure 2.10 shows the Personal Computer, and figure 2.11 shows the PC's Cables.

1. The PC consists of the following assemblies:

    a. Computer Assembly, installed with Matrox Cards.
    b. Keyboard
    c. 17'' LCD Screen
    d. Joystick Assembly
    e. Mouse
    f. Power Supply

2. The Computer Assembly is a standard high performance PC into which additional cards and proprietary software have been inserted.

3. The Computer Assembly has the following characteristics:

a.	CPU:	Petium IV
b.	Speed:	2.6 GHz
c.	Ram:	1.5 GB
d.	Operating System:	WIN2000
e.	Keyboard, Mouse:	Standard.
f.	Joystick:	Logitech Extreme 3DPRO.
g.	LCD Screen:	17" high resolution Flat Panel,1280x1024 pixel resolution.
h.	VGA to Video Converter Card	(Optional)

Interface Box (IFB)

Figure 2.12 shows the Interface Box.

1. The IFB is an adapter box that connects between the Optronic Scanner and the CDU.

2. The IFB consists of the following units:

a. An AC to DC power supply unit (110/60Hz to 28VDC)
b. Electronic video switching card (UTL1).
c. Electrical Harness to connect between the scanner and the PC.
d. Mechanical Box, which assembles the units all together.

3. The IFB includes Electrical Connectors to the main cable to the scanner (W1), and to the cable to the PC (W2). It also includes video BNC output for monitor connection.

Controls, Keyboard and Mouse

Figure 2.13 shows the Joystick.

- The Joystick is used to initiate or to stop a scan, to switch between CCD and FLIR cameras, and to fire the LRF and the Laser Pointer. In addition, the Joystick is used to control functions, requiring rapid Operator intervention, such as focus, zoom and gain/level controls. Alternatively, all Joystick operations can be performed with the Keyboard.

- The Keyboard and Mouse are used to control less frequently used functions that are available through menus on the screen, for example Scan Setup, North Calibration and Target List Control.

Screen Display – Main Display

Figure 2.14 shows the main screen.

1. Scan Mode:

When the SPIDER is operating in Scan Mode, a panoramic image is shown on the top half of the screen. Above the panoramic image there is a scale with azimuth angles for orientation. If the panoramic image is wider than the screen, the image will be split into two strips. A still wider image will be split into more strips with less resolution. The number of strips and resolution of the displayed image is automatically set by the System, in order to display the best resolution possible for a given scan range. The panoramic image is continuously updated during scanning. Automatically detected targets are marked on the panoramic image with green squares symbols. During scans, a time lapsed image of a portion of the panoramic image is enlarged and shown at the bottom left corner of the screen. The Region Of Interest (ROI) is determined by the position of a Joystick controlled crosshair on the screen.

2. Observation Mode:

When the SPIDER is operating in Observation Mode, the panoramic image is no longer updated and a live video image appears in the bottom left corner of the screen.
In Observation Mode, a second crosshair appears on the panoramic image indicating the current LOS direction for orientation purposes.

3. Subsystem Information

At the bottom center of the screen, System information and menus are displayed. Displayed information includes:

- Current date and time.
- System messages to the Operator.
- Status button, displays the current System status. Pressing the button opens a window displaying current status details. If the button is green – the System is working properly. If the button is red – there is some problem in the System. If the button is blinking – there is a new problem that hasn't been checked yet.
- Current mode of operation.
- Non-uniformity table being used by the FLIR.
- Currently used camera (CCD or FLIR).
- Scan region and number of vertical strips being scanned.
- Line of Sight (LOS) angles and state of AGC (ON/OFF).

4. Graphical representation of LOS

At the bottom right corner of the screen, a graphical representation of the scan regions and current LOS is displayed, relatively to the angles and elevation. The green square represents the current LOS. The yellow square represents the current sector that is being scanned. The red squares represent the other sectors that are defined to be scanned, but not currently scanned. Above this there is a scale of the scan quality.

5. Target coordinates

Above the graphical representation there is a window with the last measured range and calculated target coordinates.

6. Recording

It is possible to record the events displayed by the System, while it is scanning or observing. In order do start recording, press the mouse's left button on the "Start" button in the Recording box. In order to stop the recording, press the mouse's left button on the "Stop" button in the Recording box, and confirm it.

The system saves the recordings in drive D:, a removable hard disk. The percentage of the free space available on the hard disk is presented in the recording box.

2.3.3. Cable Subsystem

Figure 2.15 shows the SPIDER Cables.

The SPIDER System uses three main cables: a cable (W4) that connects the Payload with the Gimbal, a cable (W1) that connects the Gimbal with the IFB, and a cable (W2) that connects the IFB with the PC.

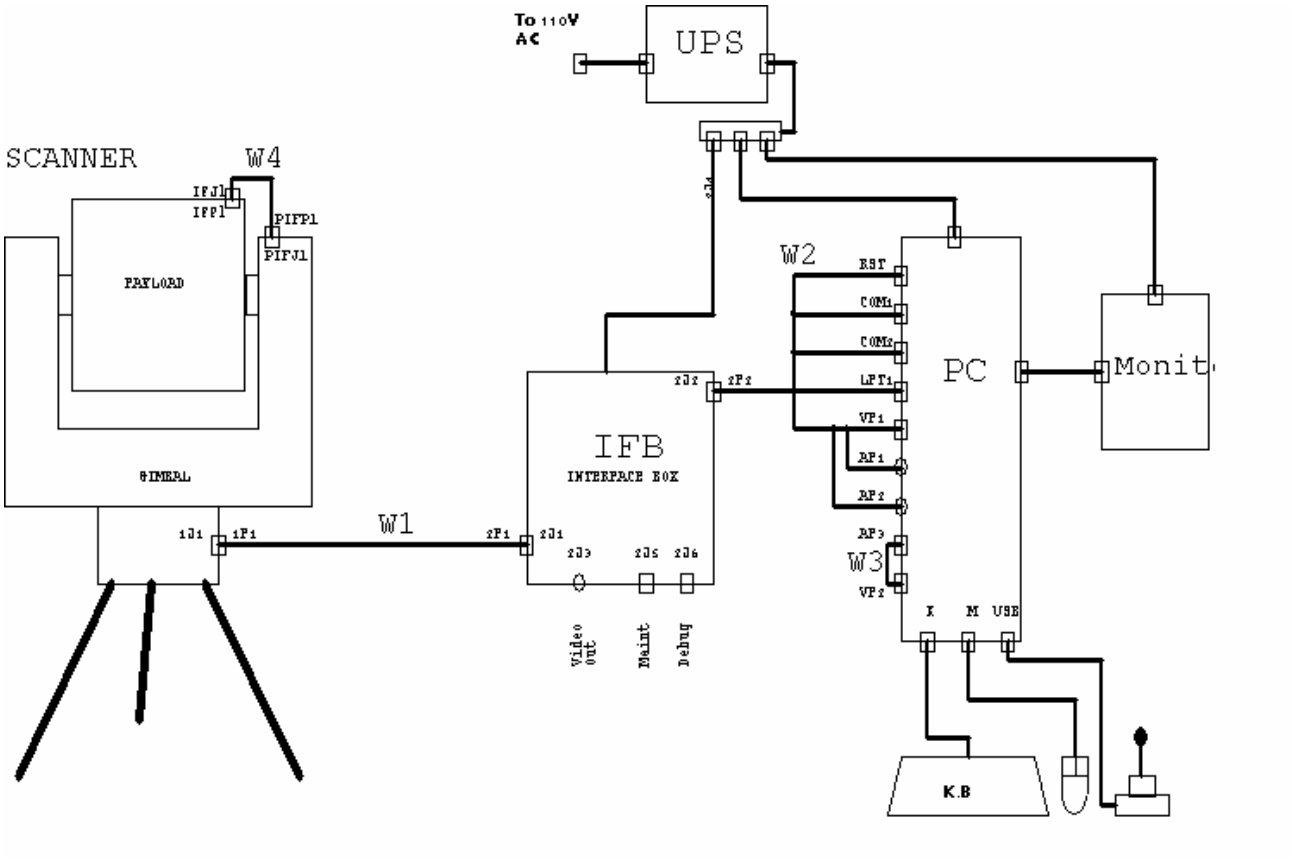

Figure 2.1 : <u>SPIDER – Block Diagram</u>

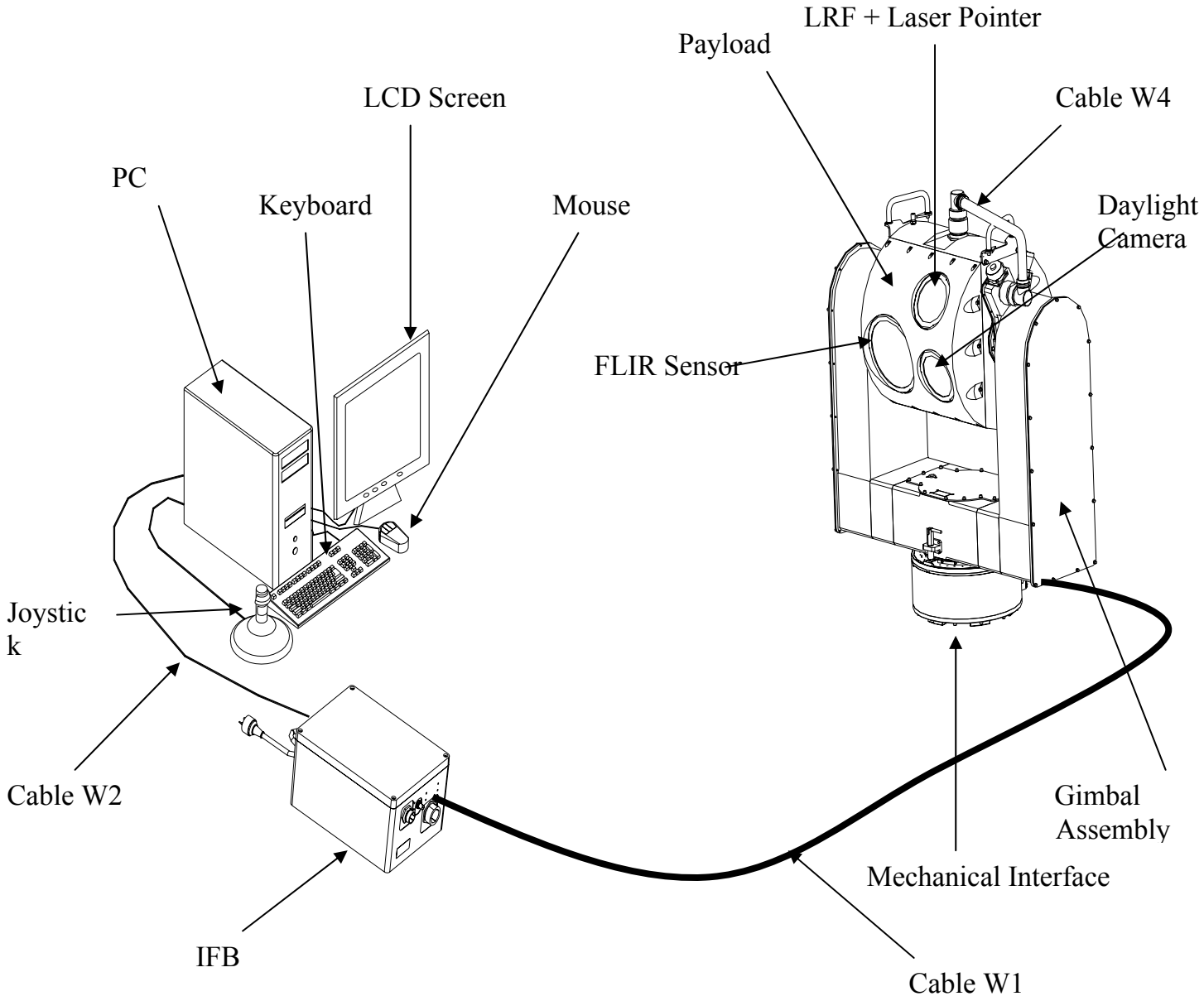

Figure 2.2: <u>SPIDER –System Configuration and Interconnection Diagram</u>

Figure 2.3: SPIDER – Scanner Subsystem

Figure 2.10: SPIDER – Personal Computer

Figure 2.12 : <u>SPIDER – Interface Box</u>

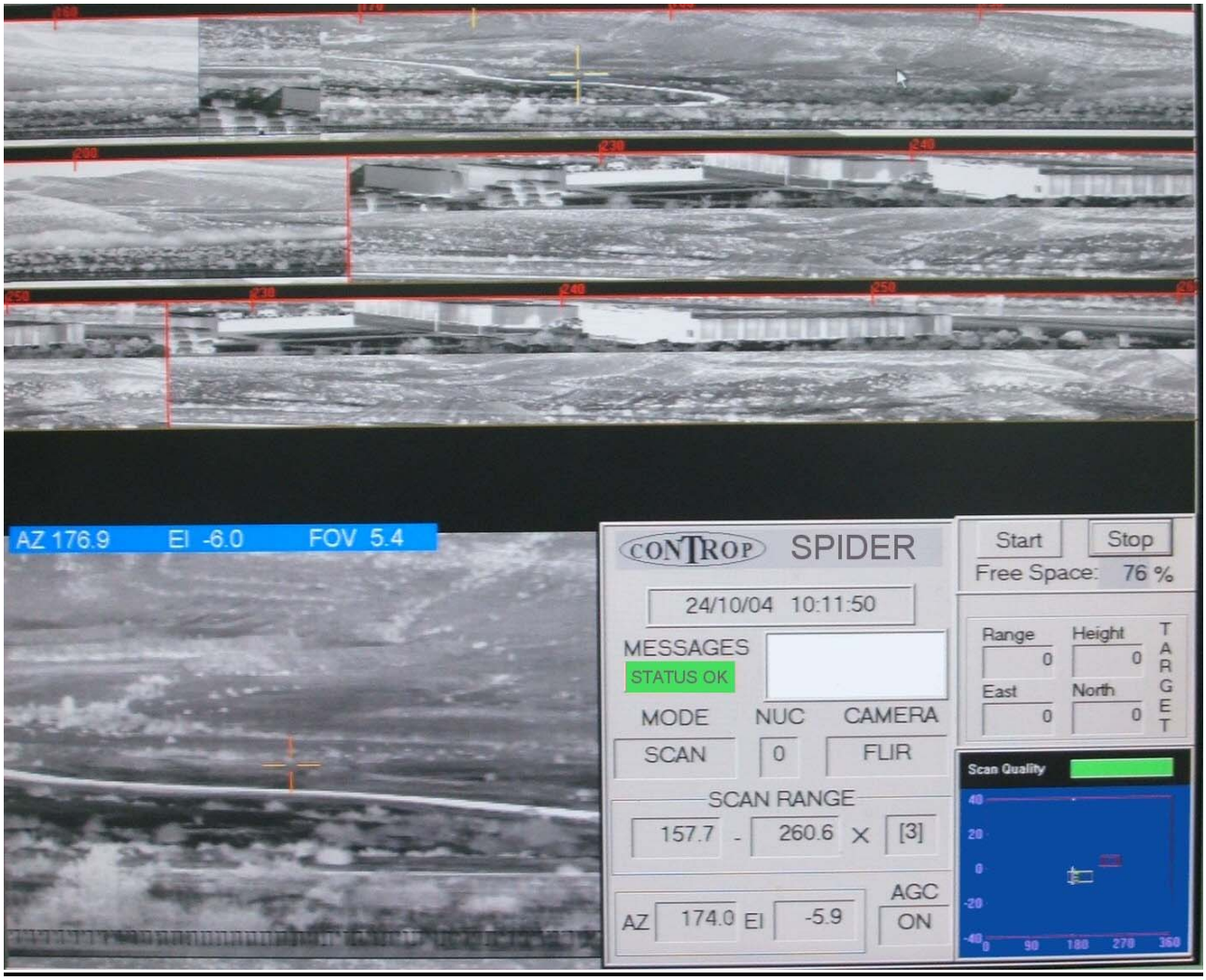

Figure 2.14: <u>SPIDER - Main screen</u>

4. SPIDER SYSTEM CHARACTERISTICS

1.1 Electro-Mechanical

a.	Field of Regard:	Horizontal: 360 ° x n (continuous)
	Vertical:	± 40 ° (Nominal)
b.	Angular Velocity:	Up to 1 rad/sec
c.	Angular Acceleration:	Up to 1 rad/sec ^{2}
d.	Scan Sector:	Up to 360°
e.	Angular Report Accuracy:	1 mrad RMS per Axis

4.2 FLIR Sensor

a.	Sensor Type:	3rd gen. Staring Array, InSb
b.	Spectral Range:	3-5 micron
c.	FPA:	320x256 pixels InSb
d.	Lens Type:	Continuous 22.5x optical zoom
e.	Video Format:	RS 170 and Digital 16 bit serial.

4.3 Daylight Sensor

a.	Camera Type:	1/3" high res. colored CCD
b.	Lens:	16x Zoom
c.	Fields of View:	
-	Narrowest FOV:	0.85° x 0.65°
-	Widest FOV:	13.6°x 10.4°
d.	Controls:	Zoom, Focus, AGC
e.	Video Standard:	NTSC

4.4 Laser Range Finder

a.	Eyesafe:	1.54 μ m
b.	Output Energy:	7 mJ (nominal)
c.	Divergence:	0.7 mrad
d.	Ranging (small targets):	up to 6 km
e.	Range Accuracy:	± 10m

4.5 Laser Pointer:

a.	Wave Length :	780nm.
b.	Output Power:	44mWatt
c.	Beam divergence:	0.2mrad

4.6 Physical Characteristics

a. Scanner Weight:
   - Gimbal Assembly: 29 kg
   - Optronic Payload: 17 kg

b. IFB Weight : 9 kg.

c. CDU Weight: 25 kg

d. Cables Weight: 15 kg.
e. Cables Length: 14 m (optional 100m)

4.7 Electrical Interface

a. Power Supply: 110/220 VAC or 28VDC
b. Power Consumption: 450W (nominal)
c. Communication: RS-422 serial channel
d. Video Output: Standard NTSC or PAL

4.8 Environmental Conditions:

a. Scanner – Outdoor environmental conditions per MIL-STD-810E:

   - Temperature: 10° to 45°C
   - Humidity: Up to 95% (non-condensing)
   - Vibration: per MIL-STD-810E
   - Shock: per MIL-STD-810E

b. CDU: Sheltered environmental conditions:

   - Temperature: +5° to +40 °C